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Length and Floor Construction of Dairy Stalls

BY HENRY GIESE AND C. Y. CANNON*

THE LENGTH OF STALL PLATFORMS

One of the problems confronting the designer of a dairy barn is to determine the proper length of the stall platform. Cows vary considerably in length, and the stall length should vary to to meet the requirements of individual cows. Stalls that are too short make uncomfortable beds, force the cows to stand with one or both hind feet in the gutter and cause them, in reaching for hay in the manger, to carry manure to the stall floor. Long stalls are equally objectionable as the droppings fall on the platform rather than in the gutter. Adjustable stanchions are available but not in general use. Where installed, the tendency is to set adjustable stanchions at the time of installation and not change them as the occupants of the stall change. Even with adjustable stanchions it would seem desirable to make the stall length approximate the needs of the herd.

Several experiment stations have, in their publications, attempted to make recommendations to guide the builder.

A few of the recommendations from literature cited at the end of this manuscript are summarized in fig. 1. This chart shows that it has been customary to suggest a range of lengths for each of the common breeds: i. e. Jersey, Guernsey, Ayrshire and Holstein, and for size ranges designated as small, medium and large. There has been no uniformity in measuring stall length. Some workers have taken it to extend to the edge of the curb, while others have designated it to the center of the curb. Dimensions in fig. 1 are all modified to measure from the center of the curb to the edge of the gutter.

From fig. 1 it is at once evident that the recommendations are indefinite and may be quite misleading because of differences

*Earl Weaver, now resigned, represented the Dairy Husbandry Subsection when the investigation of the subject of this bulletin was opened.

	Small						Medium			Large						Minimum	Maximum	Spread
	Iowa	Neb.	Wis.	W.Va.	Ky.	A.S.A.E.	Wis.	W.Va.	Ky.	Iowa	Neb.	Wis	W.Va.	Ky.	A.S.A.E.			
Holstein	5-0½	5-0	4-10½	4-10	4-10	4-10	5-2½	5-2	5-2	5-10½	5-6	5-8½	5-8	5-8	5-8	4-10	5-8½	10½
Ayrshire	4-8½	4-8	4-8½	4-6	4-6	4-6	5-2½	5-0	5-0	5-0½	5-0	5-6½	5-6	5-6	5-6	4-6	5-6½	12½
Guernsey	4-8½	4-8	4-8½	4-6	4-6	4-6	5-0½	4-10	4-10	5-0½	5-0	5-4½	5-4	5-4	5-4	4-6	5-4	10
Jersey	4-6½	4-6	4-6½	4-4	4-4	4-4	4-8½	4-8	4-8	4-10½	4-9	4-10½	5-0	5-0	5-0	4-4	5-0	8
heifers			3-10½	3-8	3-8	3-8	4-2½	3-10	3-10			4-4½	4-2	4-2	4-2	3-8	4-2	6

Fig. 1. Length of stall platform.

of opinion as to just what constitutes a small, medium or large animal of any particular breed. The standards of one farm or community may be decidedly different from those of another farm or community. It will be noted that there has been a difference of opinion amounting to several inches, as indicated by the recommendations of the various experiment stations, in the length required for the various breeds.

The study described herein was made with the thought of determining more carefully just what lengths are required for the various breeds and of finding a simpler way of stating the relationship between cow-size and stall-length.

The studies were made with the cows on the Iowa State College Dairy Farm. One set of observations was taken in the spring of 1925 and the other 3 years later. In each case the method of procedure was identical. The first study had reference to the suitability of each stall to the cow occupying it. Four men, familiar with the herd, were provided with forms as shown in fig. 2. Each man worked independently and was not informed as to the length of stall, length of cow nor her exact weight. One observation only was asked. Was the cow comfortable in the stall or should the stall be lengthened or shortened and if so, how much? Consideration was given to the ease or difficulty with which the cow could stand or lie and whether manure was dropped or carried onto the stall platform. These observations were then summarized as shown in figs. 4 and 5. Series A included observations made in 1925 and series B, those of 1928. It will be noted that in 58 cases out of 82 the difference of opinion of the several observers did not exceed 2 inches; in 34 cases it did not exceed 1 inch, and in 12 cases there was perfect agreement.

Date May, 15, 1928

Observer Bert Oderkirk

Cow no.	breed	recommended change stall length
833	H	+2
834	H	+2
560	H	+2
578	H gr.	+1
840	H	+1
577	H gr.	+2
319	H	+3
681	H	+1
835	H	0

Fig. 2. Observer's memorandum.

Each stall was then measured and its length recorded in the table alongside the recommended length. Specially made calipers were used to secure data regarding the length of the cow from shoulder point to tail head (fig.3). This was done to check the statement by Kelley and Edick[1] that to secure a tailor fit, one

[1]Kelley, M. A. R., and Edick, George L. Some factors in scientific dairy barn design. Agr. Eng. 4: 139-142. 1923.

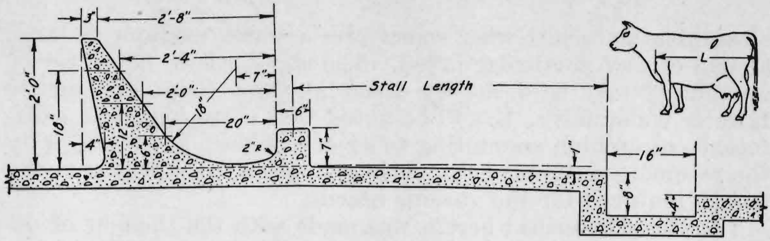


Fig. 3. Stall measurements.

should measure the length of a cow from shoulder point to tail head and add 6 inches. Weights were averaged over several months and included with the other observations.

ANALYSIS OF DATA

Figures 6, 7, and 8 show three attempts to correlate the data collected, and tabulated in figs. 4 and 5 below.

Figure 6 shows the relation existing among the cows between weight and length. Naturally there are fat cows and lean cows, long cows and short cows. The heavy line represents an approximate mathematical correlation. In all three cases, the slope of

Fig. 4. OBSERVATIONS—SERIES A

Cow no.	Breed	Weight	Length	Stall length: Rec. change present stall 1	2	3	4	Av.	Present length	Rec. length	Cow length minus stall length
249	J	994	57.8	−2	−2	−2	−1	−1.8	58.8	57.0	.8
256	G	1089	61.3	0		+2	−1	+ .3	59.6	59.9	1.4
309	A	1086	59.8		−4		−3	−3.5	63.0	59.5	.3
319	A	1332	66.3		−2	0	+1	− .3	59.3	59.3	7.0
325	G	1214	61.3	0		0	0	0	59.3	59.3	2.0
348	J	945	58.3	−2	−3	−2	−1	−2.0	58.5	56.5	1.8
375	A	1179	59.4		−8	−2	−3	−4.3	63.0	58.7	.7
384	G	989	57.8	−3		−2	−1	−2.0	58.9	56.9	.9
391	G	921	57.0	−3		−2	−2	−2.3	55.5	53.2	3.8
396	J	970	53.9		−3	0	−2	−1.7	55.0	53.3	.6
398	J	1002	55.4	−2	−2	−1	0	−1.3	57.3	56.0	− .6
403	J	963	57.0	−2	−2	−2	−2	−2.0	57.4	55.4	1.6
409	H	1337	66.1	0	+2	0		+ .7	61.6	62.3	3.8
421	H	1430	66.4		0	0	+1	+ .3	63.0	63.3	3.1
426	H	1385	65.6	+1	+2	+3	+1	+1.8	63.1	64.9	.7
429	G	1130	58.6	−2	0	0	−1	− .8	58.8	58.0	.6
454	A	1031	56.3		0		0	0	55.3	55.3	1.0
463	H	1260	62.9	−2	0	+2	−2	− .5	60.6	60.1	2.8

Fig. 4. OBSERVATIONS—SERIES A (Continued)

Cow no.	Breed	Weight	Length	Stall length: Rec. change present stall 1	2	3	4	Av.	Present length	Rec. length	Cow length minus stall length
476	H	1426	65.3		0	0	0	0	63.5	63.5	1.8
485	H	1249	61.7		−1	−2	0	−1.0	63.5	62.5	−.8
486	G	949	58.2	−1		+2	0	+ .3	57.0	57.3	.9
487	J	939	60.5		0	0	−1	− .3	54.5	54.2	6.3
493	H	1413	65.7	0	+1	+2		+1.0	63.6	64.6	1.1
499	G	963	56.6		−1	+1	−2	− .7	54.0	53.3	3.3
505	H	1184	64.5	+1	+3	+2	+1	+1.8	61.3	63.1	1.4
506	G	1065	59.8	0		−1	0	− .3	57.4	57.1	2.7
522	H	1437	66.0	+2	+2	+2		+2.0	62.0	64.0	2.0
523	J	983	57.4	0	0			0	57.0	57.0	.4
527	J	837	52.3	−1	−2	−2	−1	−1.5	56.3	54.8	−2.5
528	A	933	57.0		−5	−3	−4	−4.0	63.5	59.5	−2.5
529	G	1108	58.2	−1		0	0	− .3	56.0	55.7	2.5
540	A	1060	58.6	0	0	0	0	0	57.9	57.9	.7
543	A	963	57.0		−8	−4	−4	−5.3	63.0	57.7	− .7
547	J	902	55.8	−3	−2	−2	−2	−2.3	55.8	53.5	2.3
549	H	1069	63.7		−4		−1	−2.5	63.0	60.5	3.2
552	J	1223	60.5	0		0	−1	− .3	58.5	58.2	2.3
555	J	906	55.8	−3	−1	−2	−1	−1.8	55.4	53.6	2.2
560	H	1220	64.2	+2	0	+2	+1	+1.3	63.0	64.3	− .1
564	G	1021	57.8			0	0	0	55.3	55.3	2.5
565	J	888	56.2	−3	−2	−1	−2	−2.0	59.0	57.0	− .8
570	A	1033	55.4	−1	−2	0	−1	−1.0	57.0	56.0	− .6
573	A	1027	57.8	−2	−2	−1	−2	−1.8	57.3	55.5	2.3
577	H	1209	63.0	0	0	+1	0	+ .3	62.5	62.8	.2
578	H	1170	61.8	0		0	0	0	63.8	63.8	−2.0
590	G	972	55.8		0	+2	−1	+ .3	54.3	54.6	1.2
592	H	1223	61.7		+3	+2	0	+1.7	59.0	60.7	1.0
596	H	1101	60.5		+3	+2	0	+1.7	58.8	60.5	0
613	G	890	59.0			−1	−3	−2.0	57.8	55.8	3.2
618	G	928	59.4	0		0	−1	− .3	58.3	58.0	1.4
620	J	971	50.8	−3	−3	−4	−3	−3.3	56.0	52.7	−1.9
626	G	738	53.1	−4		−4	−4	−4.0	58.6	54.6	−1.5
643	G	862	58.8	0			0	0	56.5	56.5	2.3
688	H	1369	65.3	+2	+4	+2	+1	+2.3	60.1	62.4	2.9
559	A	1095	56.6	−1	−2	−2	−2	−1.8	57.8	56.0	.6

Fig. 4. OBSERVATIONS—SERIES B

Cow no.	Breed	Weight	Length	Stall length							Cow length minus stall length
				Rec. change present stall					Present length	Rec. length	
				1	2	3	4	Av.			
319	H	1528	68.8	+ 3	+1	+3	+4	+2.8	62.4	65.2	3.6
499	G	1049	58.2	−3	−3	−4	−2	−3.0	57.8	54.8	3.4
529	G	1166	61.8	0	+2	+1	+2	+1.3	58.8	60.1	.7
560	H	1462	65.3	+2	0	+2	+3	+1.8	63.8	65.6	− .3
565	J	1049	57.8	0	+2	0	+2	+1.0	54.8	55.8	2.0
570	A	1116	58.2	−1	0	0	0	− .3	59.8	59.5	1.3
577	H	1518	65.7	+2	+1	+2	+2	+1.8	62.8	64.6	1.1
578	H	1355	63.7	0	−1	+1	0	0	63.4	63.4	.3
620	J	871	54.7	−4	−1	−5	−4	−3.5	56.8	53.3	1.4
634	H	1237	64.5	0	0	0	+2	+ .5	61.4	61.9	2.6
675	H	1415	64.5	0	+2	+2	+3	+1.8	61.0	62.8	1.7
681	H	1496	65.7	0	0	+1	0	+ .3	62.1	62.4	3.3
685	G	983	60.2	−3	−2	−2	−3	−2.5	58.4	55.9	4.3
695	H	1336	63.0	−2	0	0	0	− .5	60.7	60.2	2.8
719	G	973	58.2	−2	−2	−2	−1	−1.8	58.1	56.3	1.9
723	J	782	54.3	−5	−3	−2	−3	−3.3	56.1	52.8	1.5
727	A	840	57.0	−5	−2	−3	−4	−3.5	59.4	55.9	1.1
737	A	1041	58.6	−3	−1	−2	−2	−2.0	59.1	57.1	1.5
815	J	815	55.5	−2	−1	−2	−1	−1.5	55.8	54.3	1.2
816	J	777	55.8	−4	−1	−3	−1	−2.3	55.4	53.1	2.7
817	J	829	56.2	−4	0	−2	−1	−1.8	55.1	53.3	2.9
818	J	718	52.7	−6	−1	−4	−3	−3.5	56.4	52.9	− .2
825	H	1006	58.2	−3	0	−2	−2	−1.8	60.0	58.2	0
826	H	1006	58.2	−3	0	−2	−3	−2.0	60.3	58.3	− .1
833	H	1349	65.7	0	0	+2	+2	+1.0	64.5	65.5	.2
834	H	1376	67.3	+2	+2	+2	+2	+2.0	64.1	66.1	1.2
835	H	1354	66.5	−1	0	0	+1	0	61.7	61.7	4.8
840	H	1372	65.3	0	+1	+1	+1	+ .8	63.1	63.9	1.4
Av.		1102	59.9							58.5	1.4

the line was slightly changed in order to simplify the equation. The differences are less than probable inaccuracies in observation. It will be readily seen that the departure of individuals from the average makes impossible any very definite or precise statement. It is believed, however, that the formulas given below are more definite than recommendations heretofore made and considerably more simple.

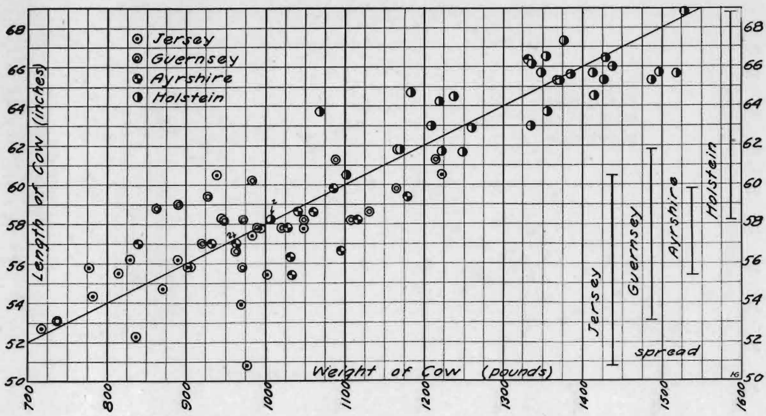


Fig. 6. Correlation between weight and length of cow.

The measurements of individual cows are located and indicated by breeds in fig. 6. No particular grouping of breeds is apparent except that the individuals of one breed may average larger than those of another. That is, one breed apparently is as close to the correlation as another. The spread of individuals within a given breed is shown at the right. Other herds might increase the spread somewhat.

The equation of the line given in fig. 6 is $\quad Lc = \frac{Wc}{50} + 38.$

That is, the length of the cow in inches is approximately one fiftieth of the cow's weight in pounds plus 38.

Figure 7 shows the relationship between the length of cow and length of stall. The individuals seem to follow more closely the line of correlation here than in fig. 6. The equation for this line, which follows almost exactly the mathematical correlation, is Ls=Lc—1.5: the length of stall, in inches is equal to the length of the cow minus 1.5. The heavy dotted line shows the recommendation of Kelley and Edick noted above, and is expressed by Ls=Lc+6. The obvious difficulty of using these equations is that of obtaining an accurate measurement of cow length. This can be taken only with a caliper and even then care must be taken to measure when the cow is in a

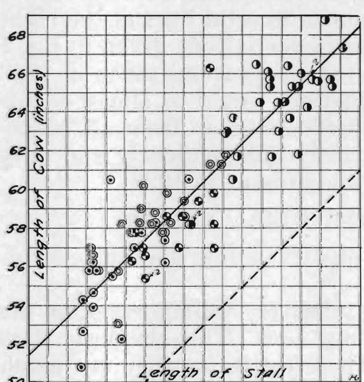


Fig. 7. Correlation between length of stall and length of cow.

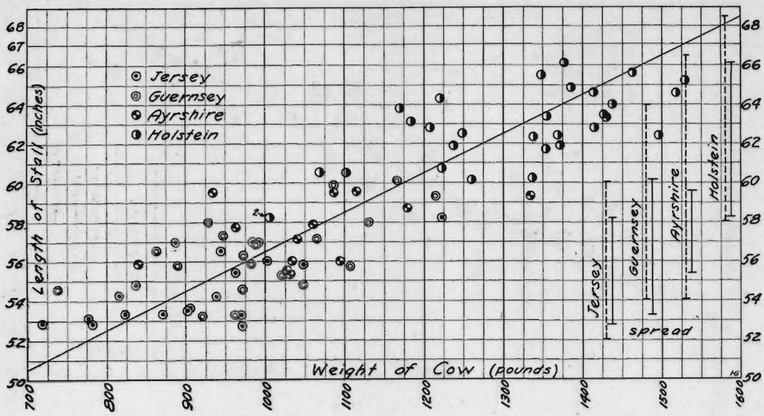


Fig. 8. Correlation between weight of cow and length of stall.

normal standing position. A slight bend in the spine will vary the length by a considerable amount.

Figure 8 was plotted because of the ease with which the data might be obtained. Farmers generally pride themselves on their ability to estimate an animal's weight. Even if this were not true, the weight can be very easily obtained. The individuals depart somewhat from the line of correlation shown in fig. 8 but as discussed above, no more than in present methods of calculation. The equation of this line is $Ls = \frac{Wc}{50} + 36.5$. The length of stall in inches is approximately equal to one-fiftieth of the weight of the cow in pounds, plus 36.5.

The spread showing the varying requirements, of stall length for animals in the college herd is shown in solid lines at the right in figs. 6 and 8. The spread of recommendations given in fig. 1 is shown in dotted lines. Note that the observations taken in 1928 corroborate those of 1925. The equations would be almost identical if taken from either set of observations or from all collectively. The observers worked entirely independently and only one observer who assisted in 1925 was present in 1928.

CONCLUSIONS REGARDING STALL LENGTH

The foregoing studies seem to justify a few general conclusions.

1. The designation of breeds is relatively unimportant in the determination of stall-size for a dairy cow. This obviously does not hold true for beef or dual-purpose cattle for they are much heavier in proportion to their length.

2. Stall-length may be estimated from either the weight or length of the cow, the length being more reliable but somewhat less easily obtained. An estimate of stall length made from

either the cow's length or weight is fairly close and easily obtained. The formulas as derived above are:

$$Ls'' = Lc - 1.5$$

and

$$Ls'' = \frac{Wc}{50} + 36.5.$$

To use these formulas in the construction of a new barn, one should first ascertain the probable size of cows which will be housed. By means of the formulas, determine the length of stall platform necessary for the largest and the smallest cow.

Instead of making the manger curb and gutter parallel, set the forms so that at one end the platform will be long enough for the longest cow and at the other end short enough for the shortest cow. The intervening stalls will approximately fit the remainder of the herd. If this plan is followed, placing the large cows on one side of a barn and the small cows on the other, with the largest and smallest at the same end (fig. 9), the litter alley will be uniformly wide in all places and the variable length of stall will not be apparent to the casual observer.

A STUDY OF DAIRY STALL FLOORING MATERIALS

The purpose of the study hereinafter described was to compare the relative merits of some materials which were thought suitable for flooring the platform of a dairy stall. Numerous questions coming to the station showed an interest in the subject. In addition to this, the cork brick flooring of 16 stalls in the col-

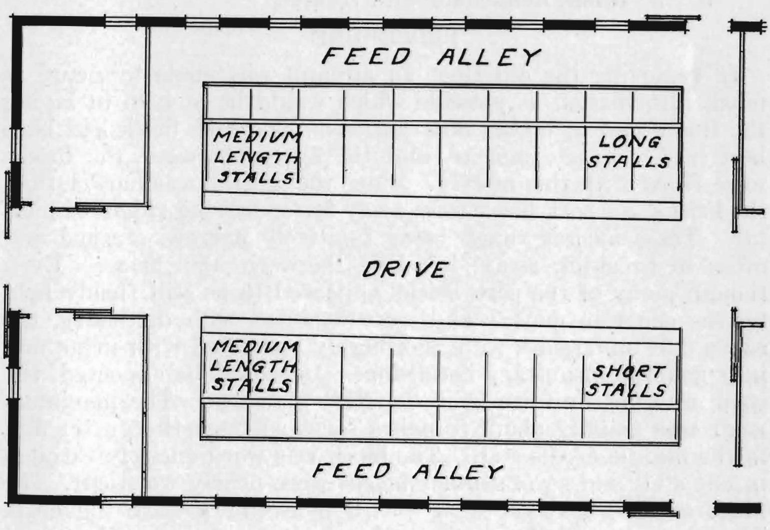


Fig. 9. Method used in varying stall lengths.

lege dairy barn were in an unsatisfactory condition and needed to be replaced. The cork brick had apparently been eminently satisfactory except that it had not given the length of service which it was felt that it should. Creosoted wood blocks which had been installed at the same time were still in good condition. The wood blocks, however, had caused some difficulty by expanding when wet and shearing off the concrete curb which separated them from the gutter. It was decided, therefore, that in resurfacing these stalls a number of materials should be used in order that comparative observations might be made. Although other studies were contemplated, only those relating to relative wear are reported here.

The following materials were selected to be used in the study. Detailed descriptions of installation and arrangement follow in the text.

Concrete
Cork brick
  a. laid in asphalt
  b. laid in cement mortar
Mastic
  a. genasco mastic
  b. bituminous concrete (paving formula)
Rubber paving block (Wright)
  a. laid over concrete
  b. laid over creosoted plank
Wood blocks (end grain yellow pine)
  a. 3″ thick, commercially treated
  b. 2″ thick, homemade and treated

PROCEDURE

In removing the old floor an attempt was made to secure as much information as possible which would be of help in laying the floors and in taking observations. The cork brick had been laid in a concrete mortar, and the spaces between the bricks were filled with this mortar. Since the mortar was harder than the bricks, the cork brick wore away faster leaving ridges of mortar. These mortar ridges being relatively narrow, cracked and often in breaking away, left holes between the brick. Even though many of the cork bricks appeared to be still firmly held by the concrete mortar and were loosened with difficulty, the edges and undersides were thoroughly saturated with urine and in a general insanitary condition. As would be expected, the wear was not uniform over the stall platform. The maximum wear was usually about 5 inches forward from the gutter and in the middle of the stall. The block was worn entirely through in one stall and several other blocks were nearly worn out. The place of next greatest wear was 9 inches back from the curb. The character of the worn surface was somewhat different at the front from that at the rear of the stall in that at the front there were two worn spots with an intervening ridge. The cow moves her hind feet considerably from side to side with the result that one hole only was worn at the rear. The stanchion is sufficiently rigid to prevent similar shifting of the front feet. From casual observation, the wear under the front feet appeared to be approximately half or less than that under the hind feet. All of the old flooring material was removed, the concrete subfloor cleaned and prepared for new surfacing. The materials used required that the sub-floor be lowered in six stanchions.

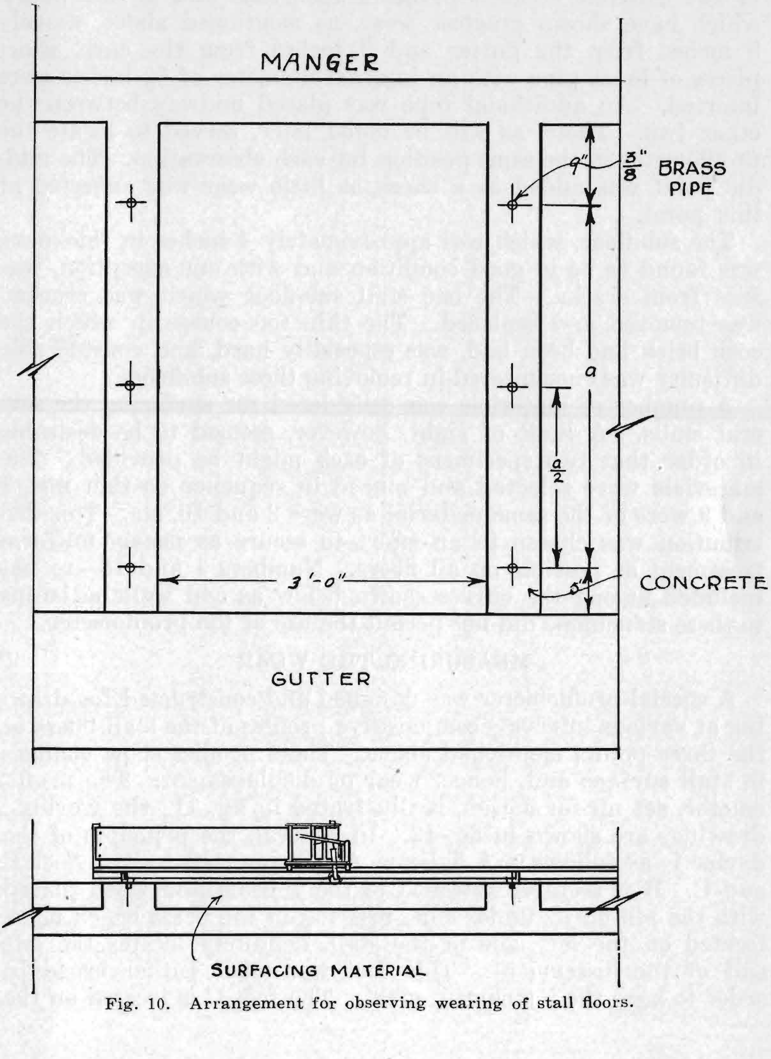


Fig. 10. Arrangement for observing wearing of stall floors.

This was done by removing the old sub-floor and laying new concrete. Care was taken not to disturb the sub-floor in adjacent stalls in order to prevent breaking the concrete strip between the stalls.

In order to maintain definite reference or bench marks, a strip of concrete was laid over the sub-floor between the stalls leaving in each case a platform 3 feet wide to be covered by the material to be tested. This construction is illustrated in fig. 10. A narrow strip of concrete was left next to the gutter as some of the materials tested needed side protection. In the center of the concrete strips separating the stalls and at the points which have shown greatest wear, as mentioned above, namely 5 inches from the gutter and 9 inches from the curb, short pieces of brass pipe with an internal diameter of $\frac{3}{8}$ inches were inserted. An additional pipe was placed midway between the other two. These, as will be noted later, served to locate the profilometer in the same position for each observation. The middle point was added as a check as little wear was expected at this point.

The sub-floor, which was approximately 4 inches in thickness, was found to be in good condition and with one exception, was free from cracks. The one stall sub-floor which was cracked was removed and replaced. The thin top course in which the cork brick had been laid, was especially hard, and considerable difficulty was encountered in removing these sub-floors.

A number of materials was considered for surfacing the several stalls. A limit of eight, however, seemed to be desirable in order that two specimens of each might be provided. The materials were selected and placed in sequence so that nos. 1 and 9 were of the same material as were 2 and 10, etc. This distribution was chosen in an effort to secure as nearly uniform treatment as possible on all floors. Numbers 1 and 16 are not included among the curves shown below as end walls adjacent to these stanchions did not permit the use of the profilometer.

MEASURING THE WEAR

A special profilometer was designed and constructed for drawing at various intervals comparative profiles of the stall floors at the three points mentioned above. These profiles show changes in stall surface and, hence, wear or displacement. The profilometer, set up for action, is illustrated in fig. 11; the working drawings are shown in fig. 12. In general, the principle of the device is as follows: A T beam A is supported by two feet B and C. B is securely fastened to the T beam and when placed with the pin on its under side, inserted in the brass bench mark located on the left side of the stall, definitely locates the left end of the instrument. This foot was made rather broad in order to keep the instrument erect. The foot C is located on the

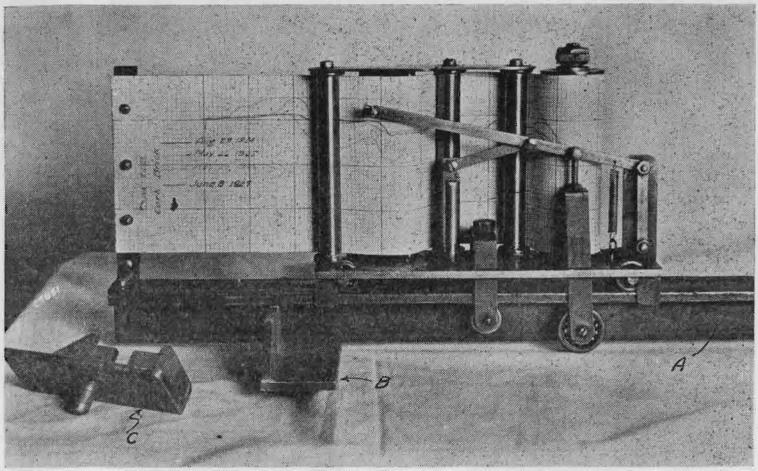


Fig. 11. Profilometer used in measuring contour of stall surface.

right side of the stall in the corresponding brass pipe. As there was some variation in stall width, it was necessary to make this part so that it would slide along the T beam. A carriage was made to run on the T beam and so arranged as to be held firmly against it at all times. The essential parts of this carriage are D, a spool to carry the record strips (the spool is provided with a friction device to prevent unrolling of the strip) and E, a straight line mechanism which records at F any vertical motion of the wheel G. The vertical movements are exaggerated four times. While in use the record strip is wrapped around the roll D, properly threaded through the machine and one end of the strip is firmly fastened at H. As the carriage is moved to the right, the pencil of the straight line mechanism traces a profile similar to the stall surface but with its ordinates exaggerated four times.

So much bitumen and mortar had been spilled in laying the floor that it was felt that reliable profiles could not be taken for some time. The stalls were resurfaced in June 1924. The first profiles were taken Aug. 29, 1924. Additional sets of profiles were taken in succeeding years. In each case the same record strips were used, one strip for each set of bench marks, and thus several comparative curves were plotted on the same sheet. The dates of later observations were May 26, 1925, May 27, 1926, June 8, 1927 and May 24, 1928.

PREPARATION OF CURVES

The curves gave very good pictures of just what was happening on the stall surface. On account of the fact that they mul-

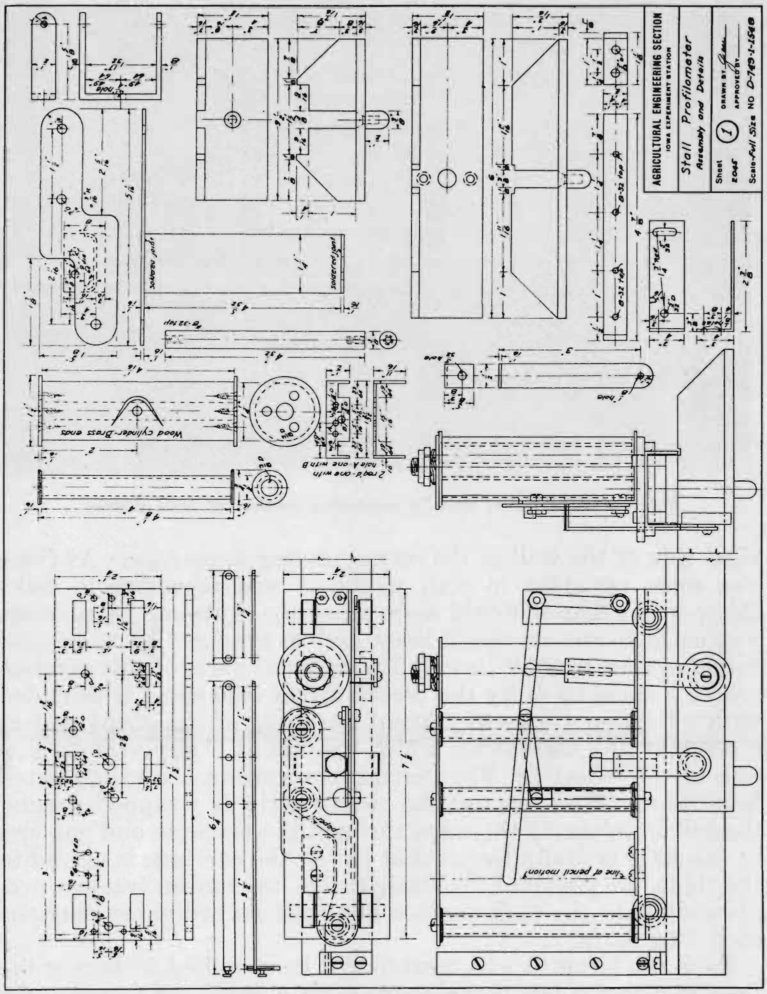


Fig. 12. Profilometer details.

tiplied the actual wear by four times, a small change in stall surface was readily observed. The next problem was to reproduce these curves so that others could get the story from them. To photograph them small enough for bulletin publication would mean to destroy the contrast which was so clearly shown on the originals.

The desired end was to get a curve which when reproduced on the bulletin page would show the wear (ordinates) actual size. Since the length of the curve (abscissa) is relatively unimportant, it seemed convenient to reduce it to the width of the printed bulletin page or 4 inches. A modified pantograph was constructed for this purpose. This is shown in operation in fig. 13 and in detail in fig. 14. Because it is believed that this device may find frequent use in reducing profiles and other curves, a description is given here. The operation is quite simple. The entire pantograph is mounted on a carriage free to move vertically but fixed horizontally. The small gear wheels supporting the pantograph are both fixed to the axle so that they must rotate together. Both run on parallel racks, thereby assuring a definite vertical motion of the entire instrument. Any vertical motion

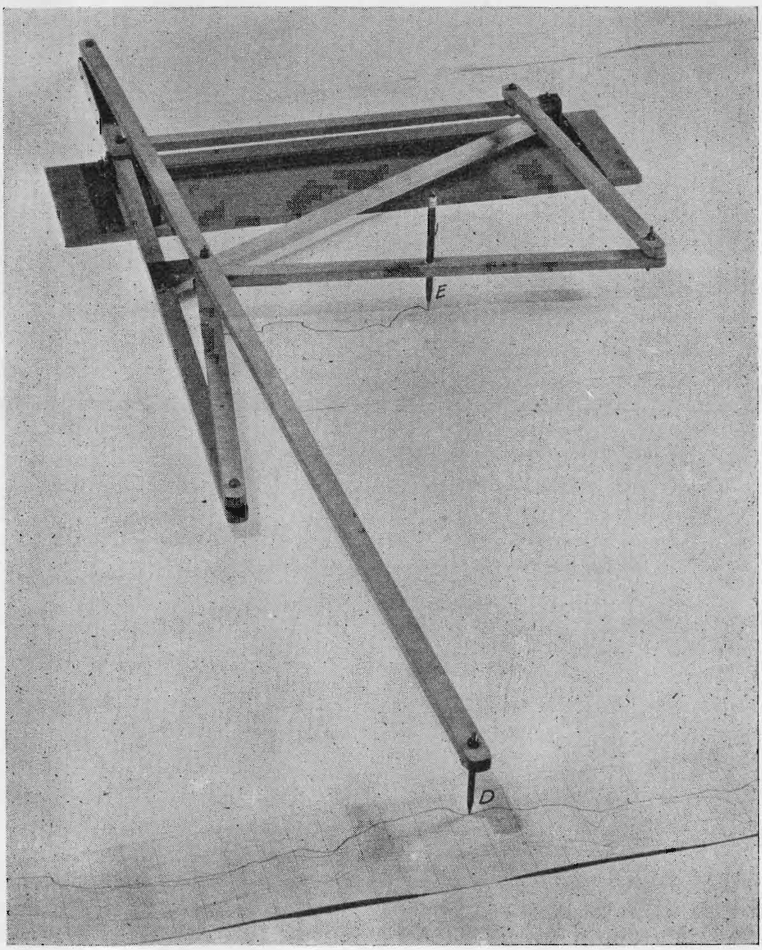


Fig. 13. Modified pantograph used in shortening profiles.

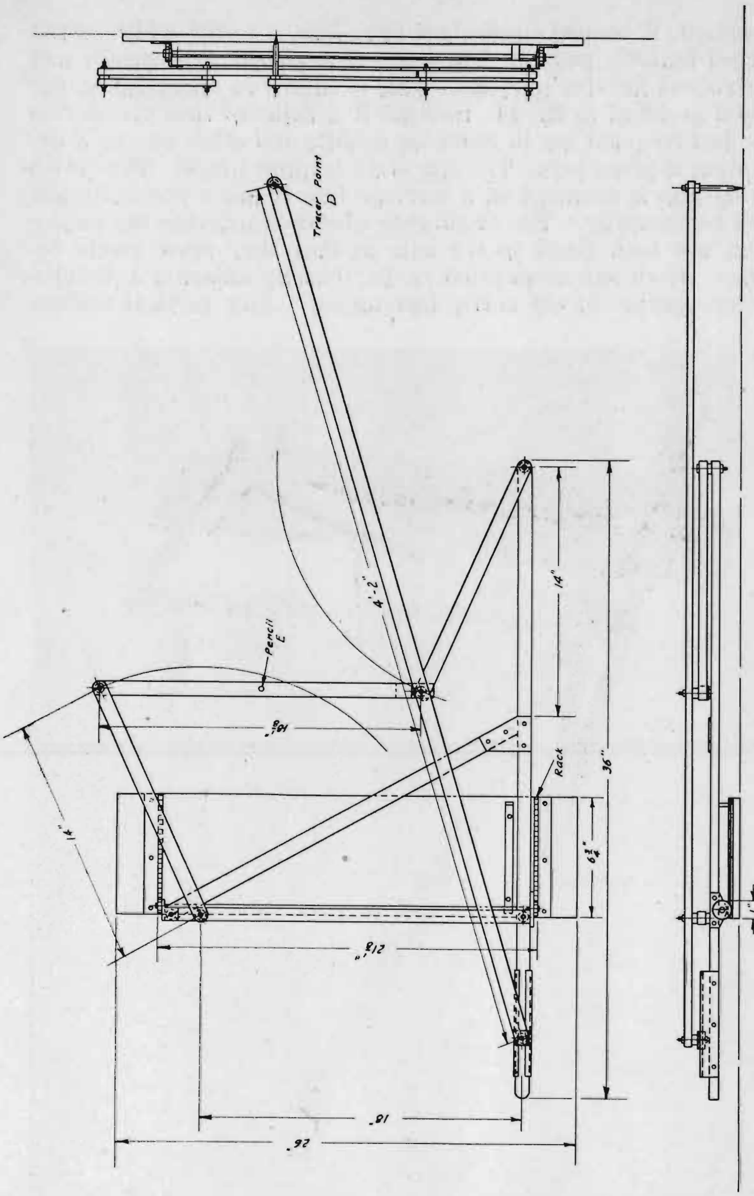


Fig. 14. Pantograph details.

of the tracer point D is transmitted in full to the pencil point E as they both move together vertically. This relationship does not apply to horizontal motion. The levers are so arranged that if the gears are firmly held on the racks and are not permitted to rotate, the tracer point is free to move only in a line perpendicular to the racks. Any motion of this tracer point is accompanied by a parallel and proportional movement of the pencil point. For the purposes of this study, the ratio used was 40 to 16. Other ratios can be obtained by changing the spacing of the holes in the various levers. By means of the pantograph, the curves as originally recorded by the profilometer have been reduced so that the column width indicates the total stall width. The ordinates have been reduced to show actual wear. The distance between a line drawn in 1924 and another drawn in 1928 indicates in true proportion the amount of material that has been worn away.

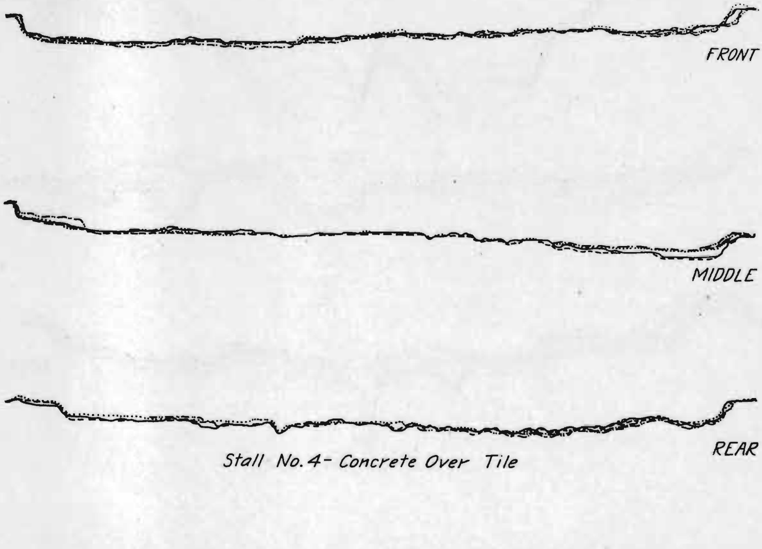
In the following pages will be discussed each type of flooring material in connection with the wear curves.

CONCRETE

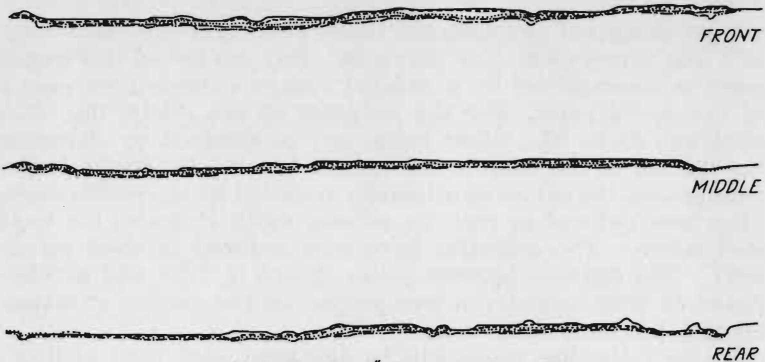
Stalls nos. 4 and 12 were surfaced with concrete, made in the proportion of 1 part of cement to 3 parts of bank run gravel composed almost entirely of fine aggregate. About 6 gallons of water were used to the sack of cement. After the concrete was poured it was finished with a wood float, giving a slightly roughened surface to minimize slipperiness. The accompanying profiles show that the wear was almost negligible. It should be noted in examining the profiles, that in reducing the length to one-tenth size any irregularities are greatly magnified, and a seemingly rough floor, as observed from the profiles, may be surprisingly smooth and regular.

CORK BRICK

Cork brick was laid originally in stalls nos. 3 and 11. In the

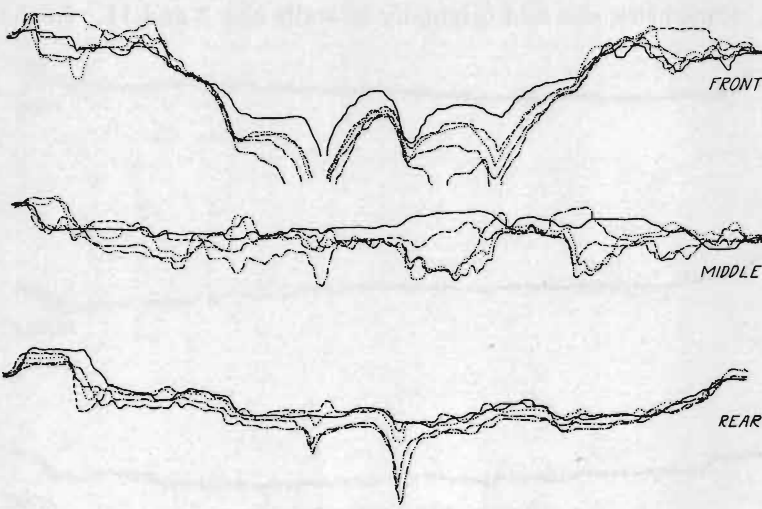


Stall No. 4 - Concrete Over Tile

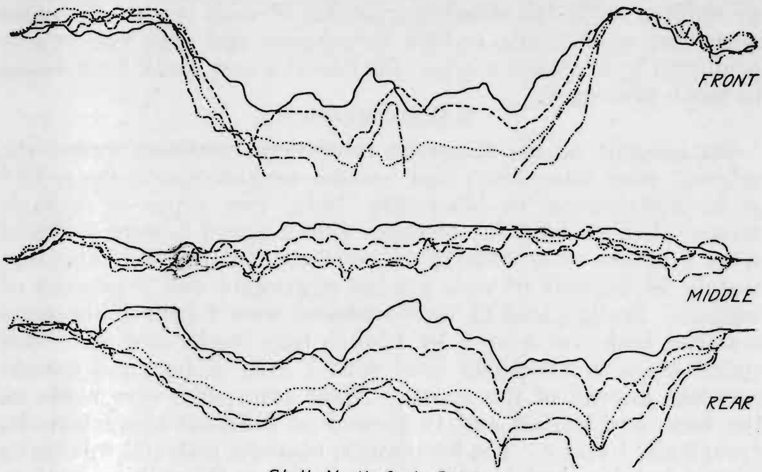


Stall No. 12 - 1" Concrete Over Tile

discussion relating to the condition of the old floor, it was noted that the concrete in which the cork brick was bedded, cracked sufficiently to permit the liquids to seep around and under the brick causing an apparently insanitary condition. In an attempt to remedy this situation, the cork brick in stalls nos. 3 and 11 was laid in an asphalt bed, and an asphalt filler was used between the blocks. This change did not prove entirely satisfactory. Even though the layer of asphalt under the cork brick was quite thin, there was some tendency for the asphalt to flow under the pressure of the animal's weight and for the bricks directly under the cow's feet to move from their original position. This movement of the blocks and asphalt is evidenced by the fact that in some stalls the floor in places was raised to a position higher than that shown in the original profile. The asphalt filler between the

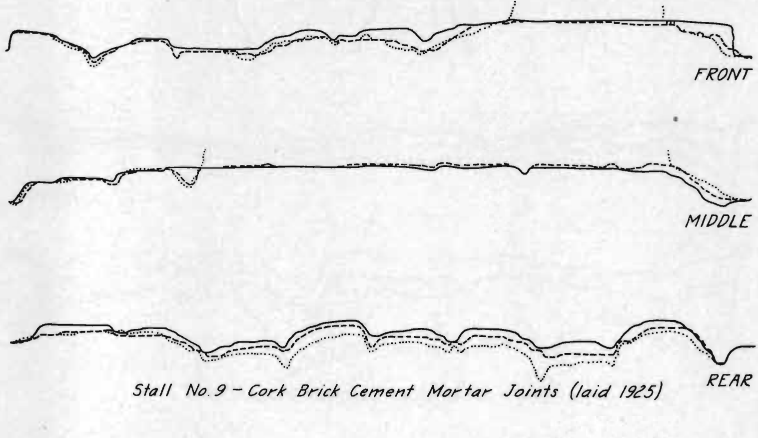


Stall No. 3 - Cork Brick



Stall No. 11 - Cork Brick

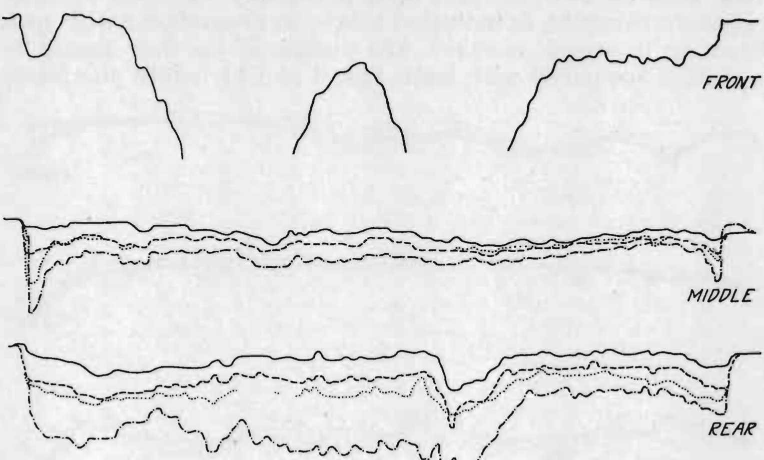
joints being somewhat softer than the brick, wore away leaving the edges of the cork brick unprotected. The wear was particularly excessive under the front feet. This apparently does not agree with the observations on the original floor, which was removed at the time this project was started. One probable reason is that Holstein cows were placed in the stalls intended for shorter animals. Several cows were too long for the stalls in which they were placed and stood with their hind feet in the gutter a considerable portion of the time. On account of the difficulties encountered with the cork brick laid in asphalt, in 1925 stall no. 9 which had been previously surfaced with bituminous concrete, as indicated below, was resurfaced with cork brick set in cement mortar. The profiles of the floor should be carefully compared with stalls nos. 3 and 11 before one forms



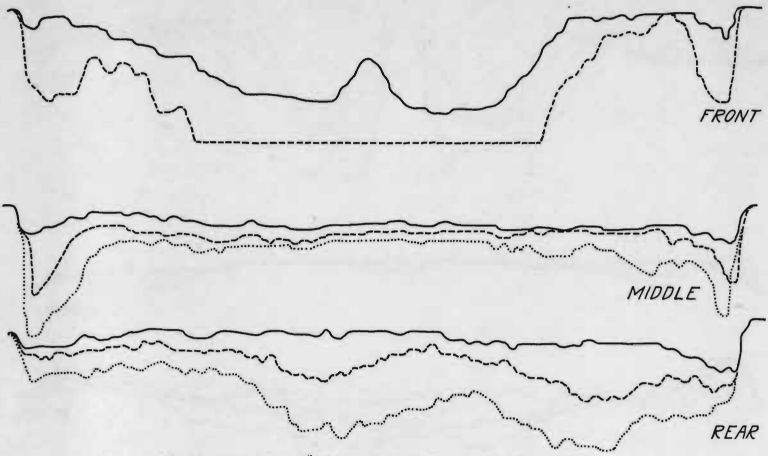
Stall No. 9 – Cork Brick Cement Mortar Joints (laid 1925) an opinion as to the wearing qualities of cork brick. It would seem that when firmly bedded in concrete and with the corners protected by a cement mortar, the life of a cork brick floor would be much prolonged.

MASTIC FLOORS

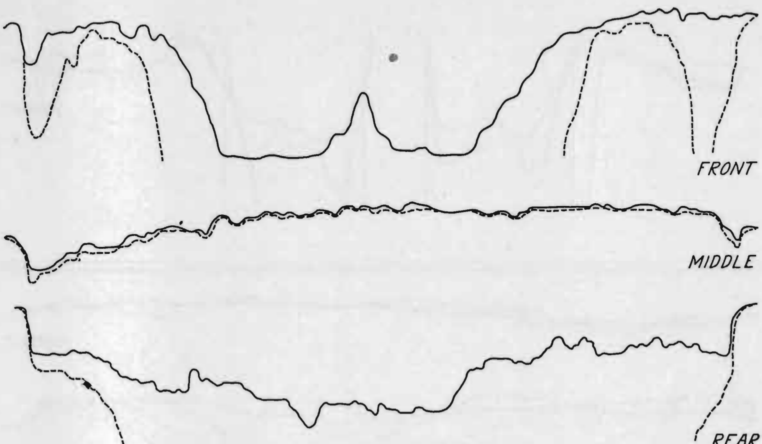
On account of the apparent insanitary condition under the original cork brick floors and because asphalt mastic floors had given satisfaction in laboratory tests, two types of asphalt mastic were selected for testing. Stalls 1 and 9 were surfaced with 2 inches of a bituminous concrete composed of approximately 91 percent of well graded aggregate and 9 percent of asphalt. Stalls 6 and 14 were surfaced with 1 inch of the same material laid over 5 by 8 by 12-inch clay blocks laid flat. This construction is commonly used with 1 inch of portland cement concrete instead of the mastic. Wear tests only were made on the floor, and stalls 6 and 14 showed no different characteristics from stalls 1 and 9. The bituminous concrete material was taken from a batch mixed for patching paving on the college campus. Stalls 5 and 13 were surfaced with 1 inch of Genasco Mastic secured from the General Asphalt Company. While the general characteristics of these floors were the same, the Genasco mastic was more resistant to wear than the other bituminous concrete. Since no. 1 is an end stall, no curves of it are available. It will be noted that the floor in no. 9 was entirely worn away at both front and rear, by 1925. Although nos. 5 and 13 lasted much longer, mastic floors have not proved satisfactory for dairy stalls. The first reason why mastic floors have been unsatisfactory is that asphalt tends to flow under constant pressure even when it is cold and apparently hard. This has been particularly



Stall No. 6 – Bituminous Concrete Over Tile



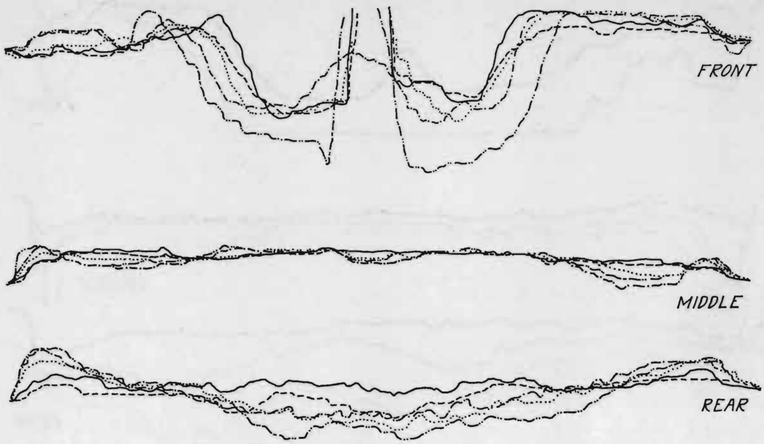
Stall No. 14 - 1" Bituminous Concrete Over Tile



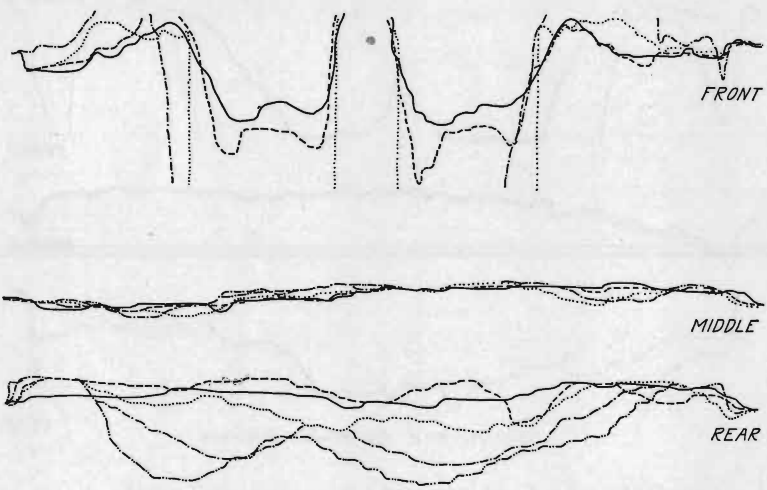
Stall No. 9 - 2" Bituminous Concrete

evident under the front feet, which occupy practically the same position throughout the time the cow is in the stall. The result, as shown by the profiles, is deep depressions where the front feet stand, with a decided rise around and especially between the feet. This change in the floor surface occurred to such an extent that the profilometer would not record it, and occasionally it was necessary to chip the mastic away to permit the T beam to rest on the feet which were provided at the ends. This situation occurred to a less extent under the hind feet.

These mastic floors also were somewhat affected by the liquids present and were usually soft and sticky on the surface. Stall no. 9 was resurfaced with cork brick in 1925.



Stall No. 5 - Genasco Mastic



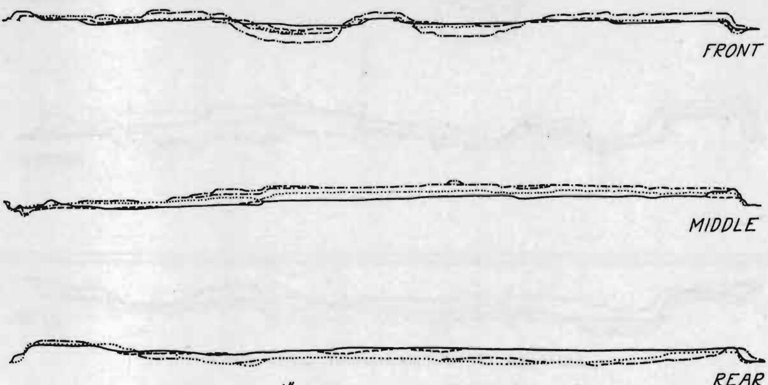
Stall No. 13 - Genasco Mastic 1" Over Concrete

RUBBER PAVING BLOCKS

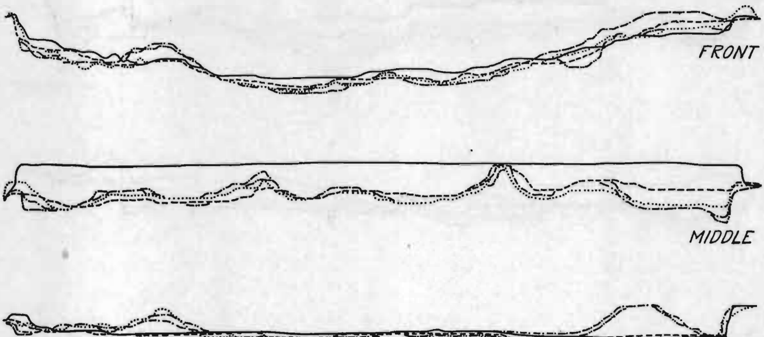
Two stalls were surfaced with rubber paving blocks secured from the Wright Rubber Tile Company. On stall no. 7 smooth surfaced blocks ½ by 6 by 12-inches were cemented to a concrete sub-floor. On stall no. 15, the blocks were nailed to creosoted wood planks which were, in turn, set in an asphalt base. The blocks used in stall no. 15 were provided with small "v" grooves 2 inches apart to prevent them from slipping. The wear on the rubber blocks was almost negligible. Stall no. 15 is likely to be misleading because of the flow of the asphalt, as mentioned above, under the cork brick and mastic. The change in profile was due almost entirely to the settling of the planks. Some of the asphalt was forced upward between the planks, and the blocks above produced the irregularities shown on the profiles. The only difficulty encountered on stall no. 7 was to prevent the liquids from seeping under the blocks and loosening the cement. The corrugated blocks used in no. 15 are hard to clean and apparently no more satisfactory than the smooth ones.

WOOD BLOCKS

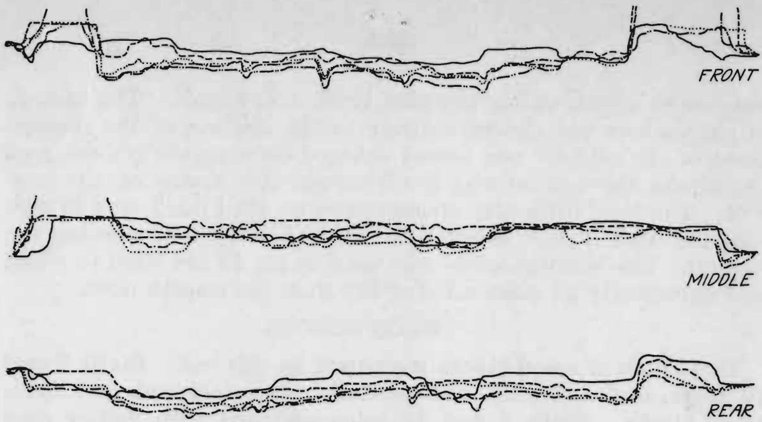
Two kinds of wood blocks were used in this test. Stalls 2 and 10 were surfaced with commercially manufactured and creosoted blocks. Stalls 8 and 16 were surfaced with yellow pine blocks made and treated by the non-pressure method by the department of forestry. Curves on all of these floors must be considered as those of rubber paving blocks mentioned above. The asphalt bed proved very satisfactory from a sanitary stand-



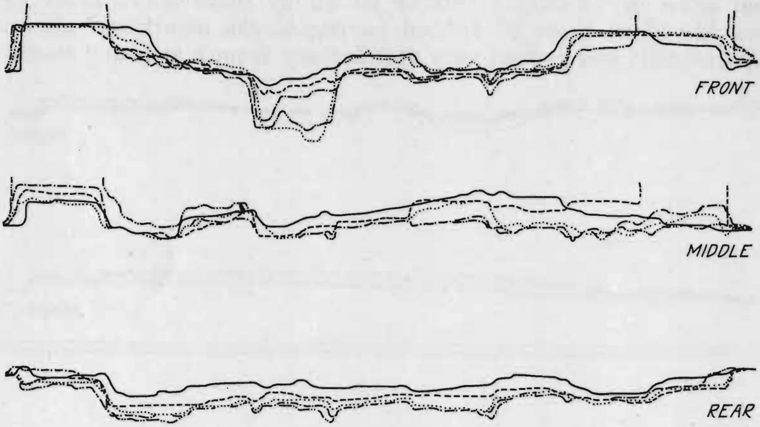
Stall No. 7 – ½" Rubber Block Over Concrete



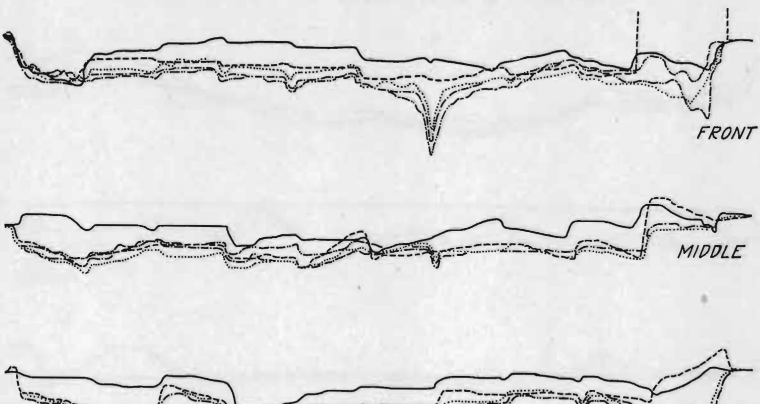
Stall No. 15 – ½" Rubber Block Over Creosoted Plank



Stall No. 2 - 3" Commercial Wood Block



Stall No. 10 - 3" Commercial Wood Block



Stall No. 8 - 2" Wood Block - Homemade point but was not stable. It will be noted that blocks in the middle of the stall settled to the solid concrete below, while in some cases those near the outside were forced upward. All wood blocks proved quite satisfactory from the standpoint of wear. The home creosoted blocks showed no difficulties due to treatment. Wood blocks should be longer than 2 inches as the 2-inch floor showed some tendency to bridge when wet.

SUMMARY

Of the several stall floor materials tested, the wear on portland cement concrete and rubber paving blocks was so slight as to be almost negligible. The wood blocks would probably have shown but little more wear than the concrete and rubber if they had been laid in concrete rather than asphalt. Asphalt was used for sanitary reasons. Asphalt, however, was found to "flow" under continuous pressure even when it was cold and apparently hard. It should not be used as a foundation where concentrated and fairly continuous pressures exist. Cork brick lasted fairly well when laid in portland cement mortar and when mortar was used in the spaces between the bricks so that their edges were protected.

Mastic floors proved undesirable owing to the tendency of asphalt to "flow" under pressure and to the concentrated application of loads in dairy stalls.

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